6-Dimensional Muon cooling with a planar snake lattice

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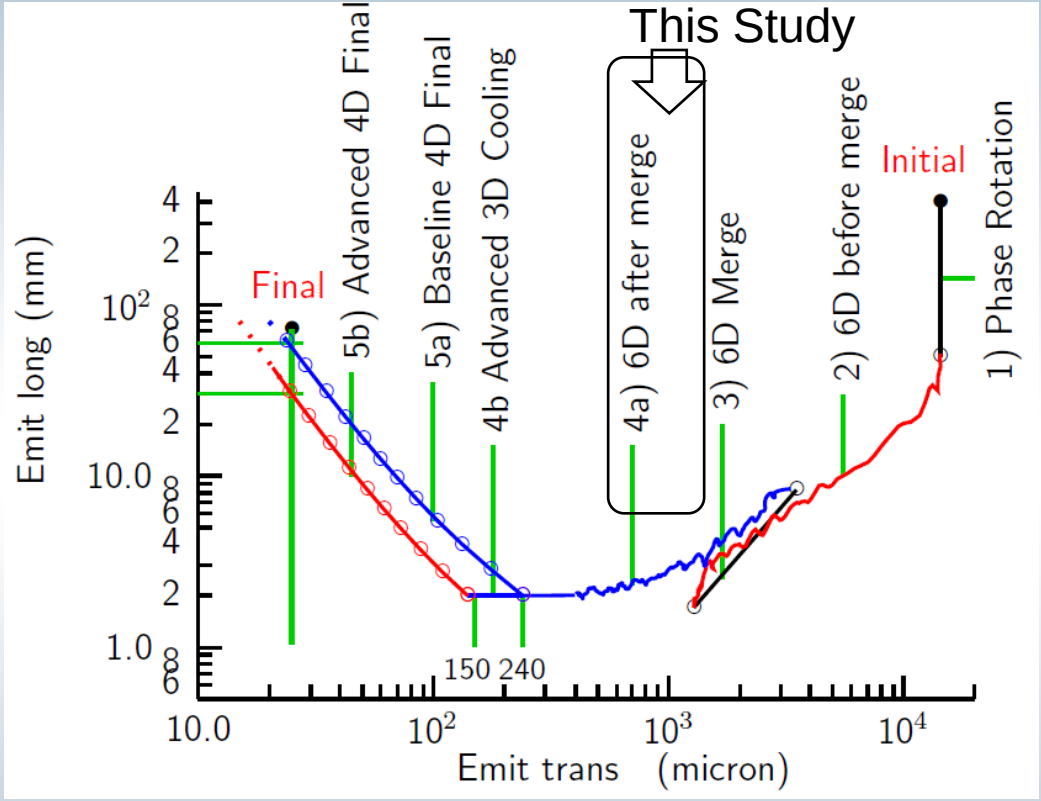
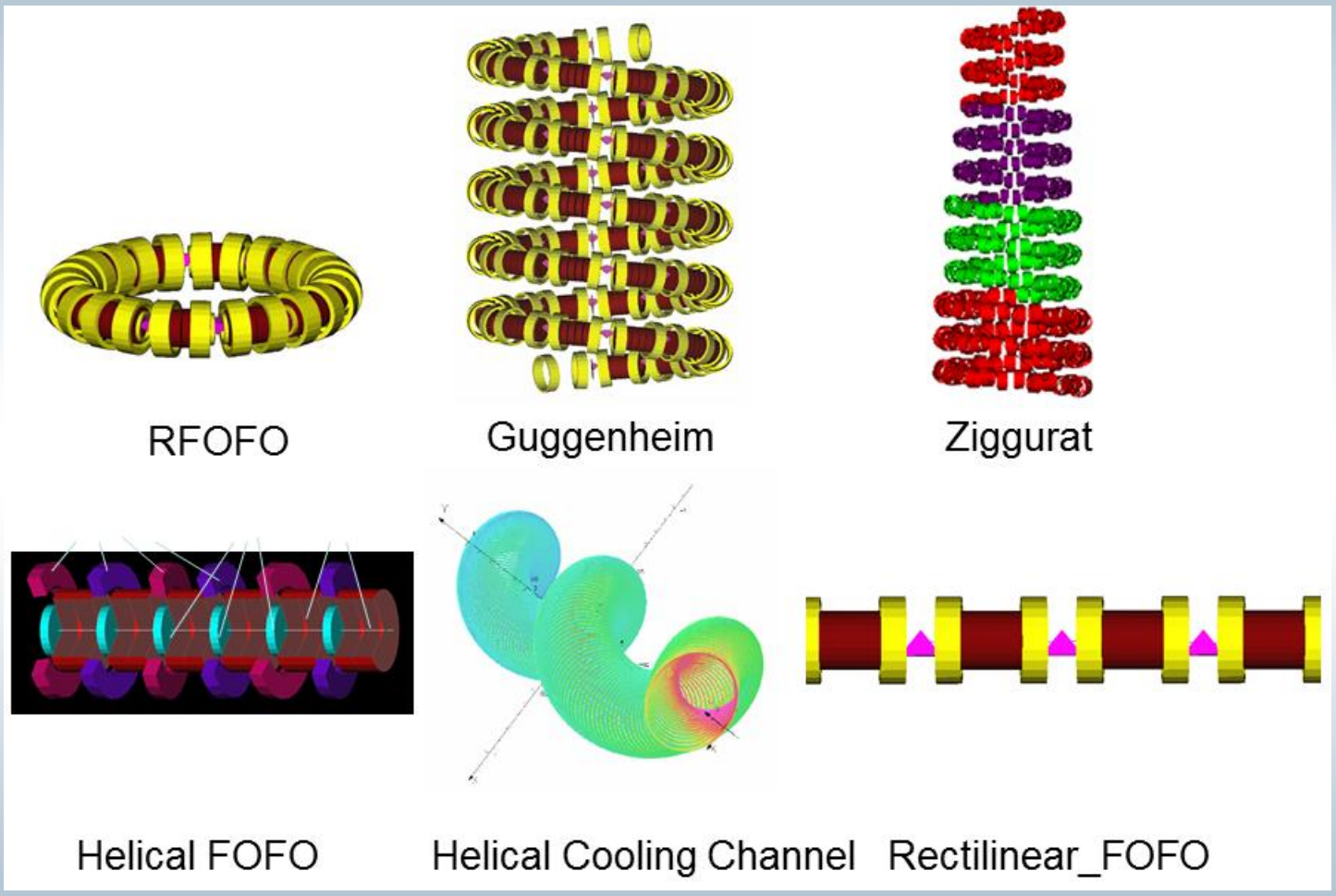
Motivation



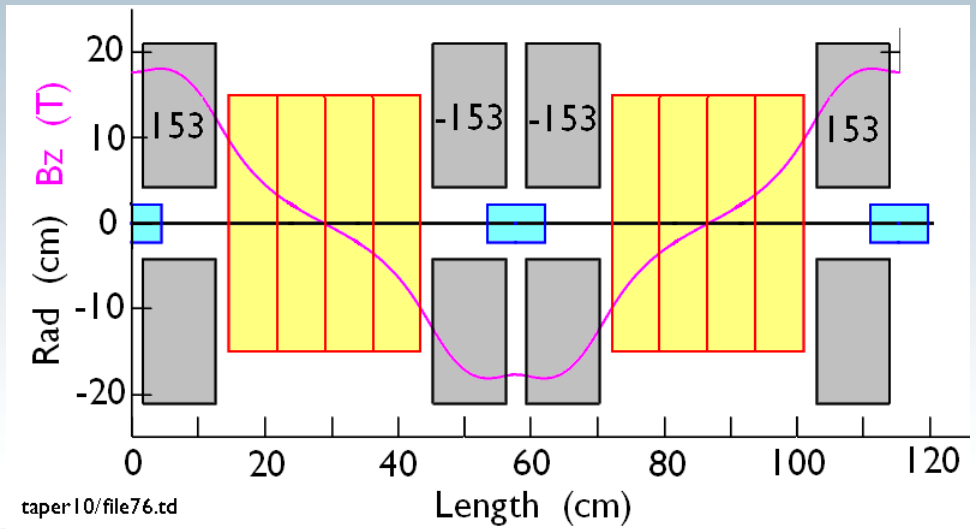
- Design and simulate a 6D ionization cooling channel
  - Key component for a Muon Collider (MC)
  - We start from the hard part: The post-merge cooler

Various 6D Cooling Channels



- I will not address pros & cons of each scheme but instead I will present a new scheme that looks promising

NEW: Planar Snake



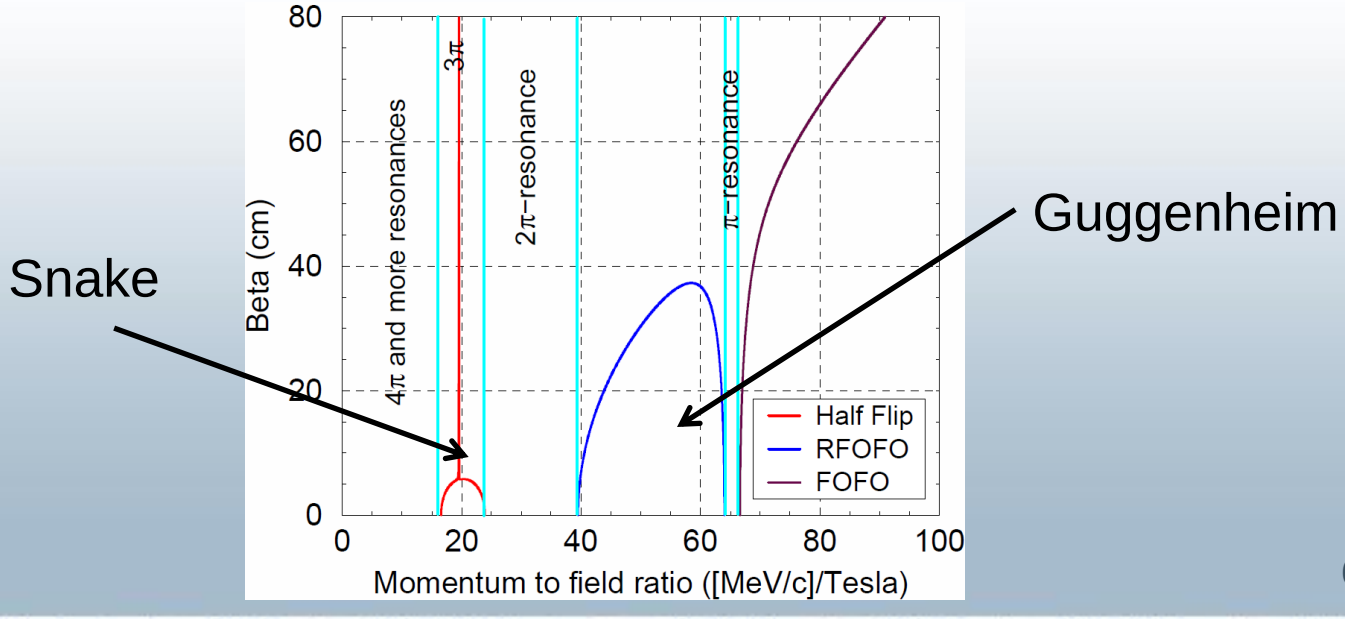
- Channel is linear
  - Most likely less engineering challenges
- Use block absorbers
  - Easier to make (compared to wedges)
  - Cools muons of both signs
- Same polarity coils on left & right side of absorber
  - Most likely more robust to forces between coils

Scope of this work

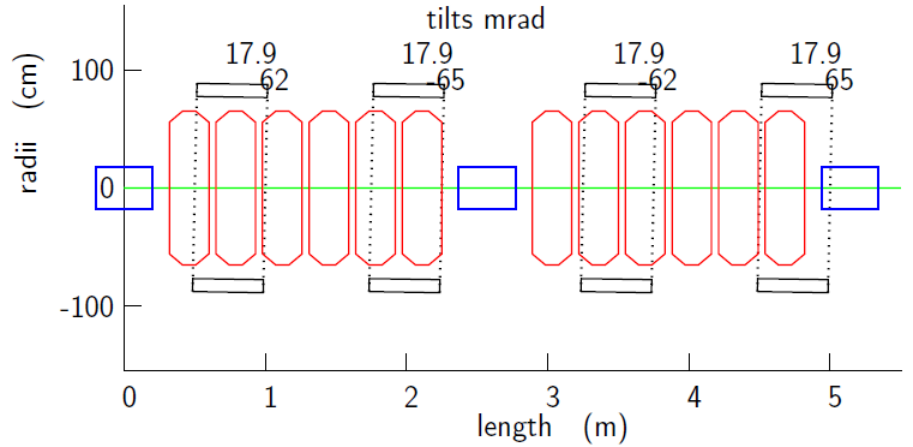
- I will present a short introduction of a planar snake lattice
- Discuss beam dynamics & lattice functions
- Design an early stage, β~30 cm
  - At the beginning of the cooling channel
- Design an late stage, β~2 cm
  - At the end of the cooling channel
- Simulate above stages and verify concept with both ICOOL and G4Beamline codes

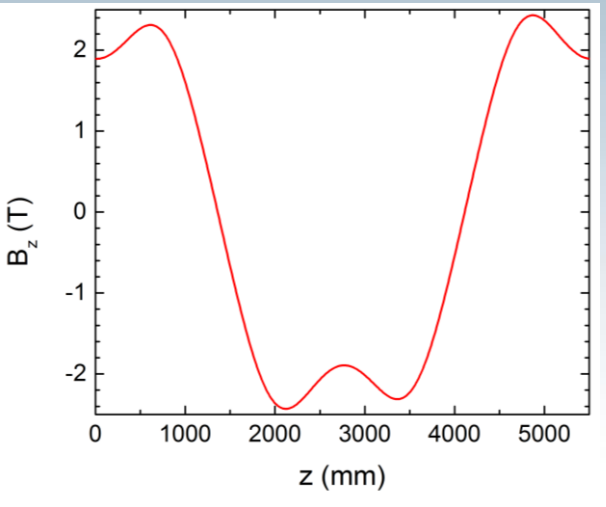
Lattice Functions

- With bending (required for dispersion) the symmetry is broken and a resonance exists in the center of the pass band
- We use the wider space 2π to 3π: giving less momentum acceptance, but seems ok

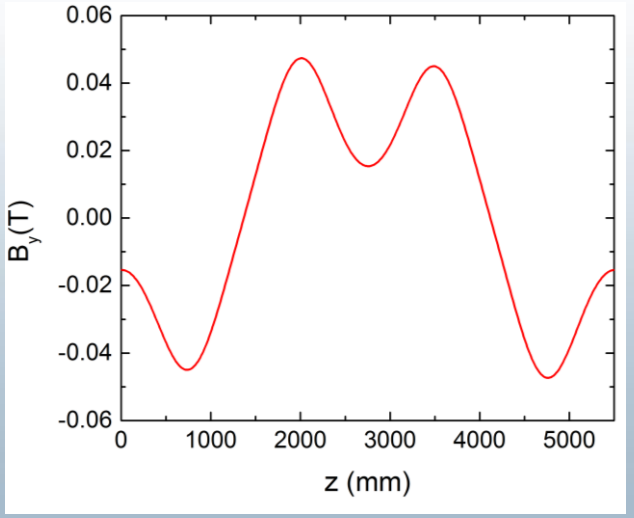


Planar Snake (Early Stage)

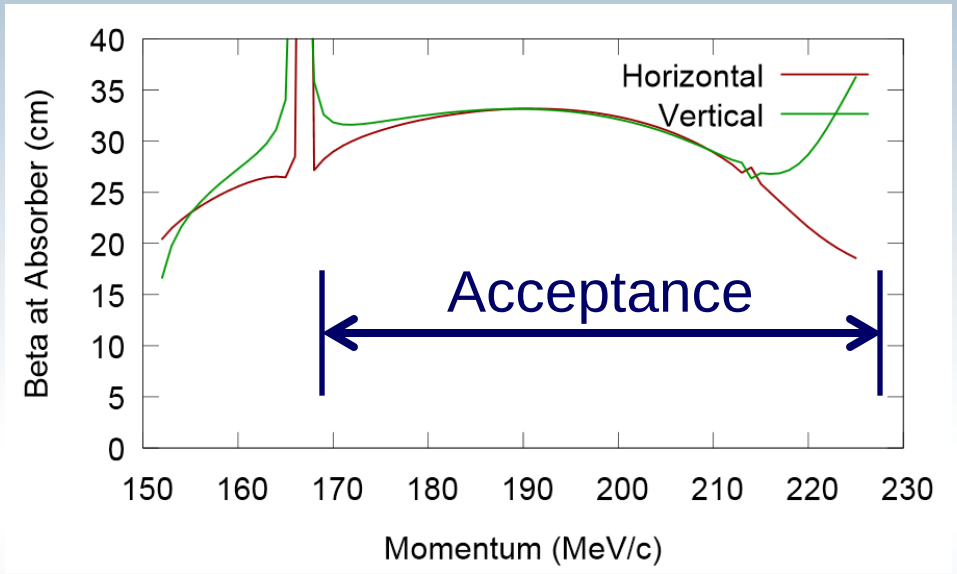


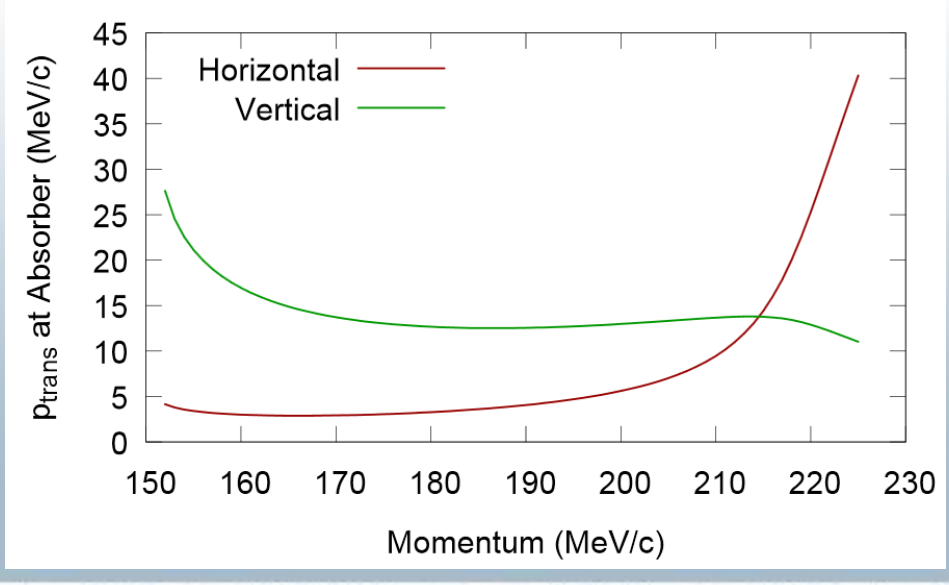


Property	Value
Lattice period	5.5 m
RF Frequency/ RF number	201.25 MHz / 12
RF voltage	17.0 MV/m
Synchronous phase	30 deg.
Absorber Length/ Type	42.6 cm/ LH2
Minimal beta function	31.5 cm
Max Field on Coil	5.2 T
Max Field on Axis	2.4 T



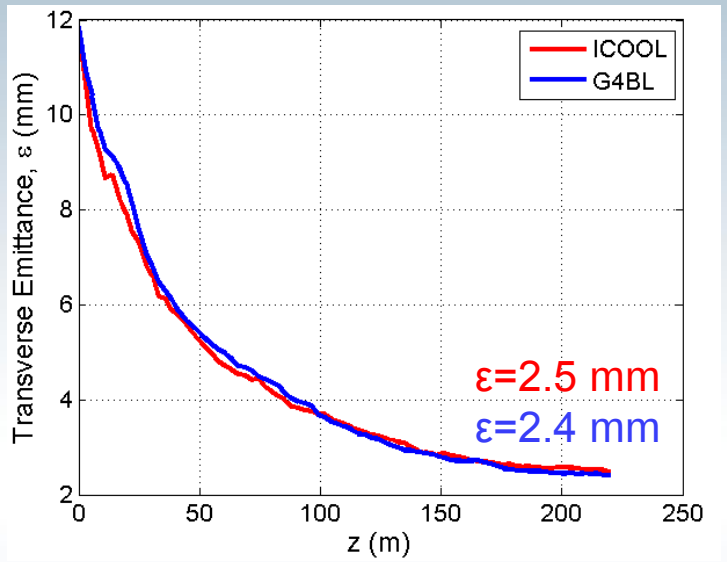
Early Stage: Lattice Functions

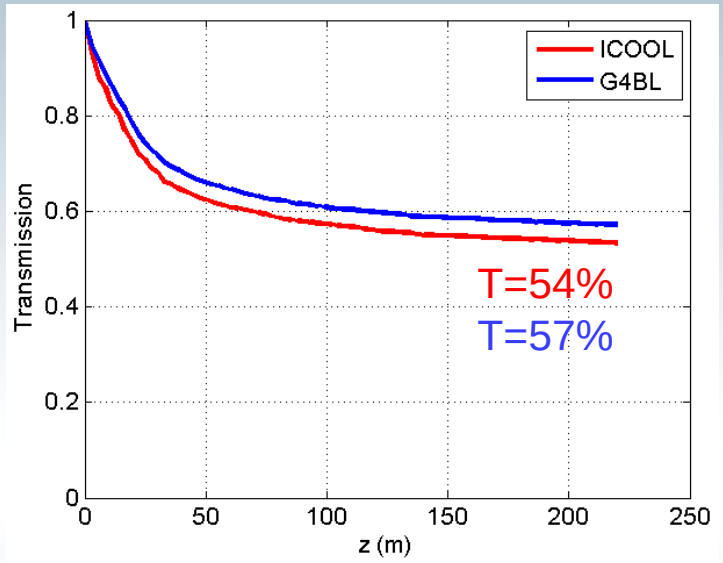


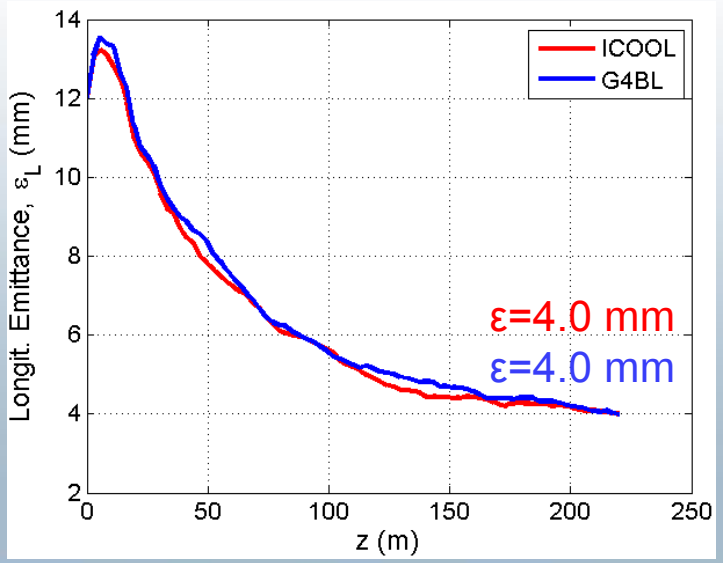


Scott Berg

Early Stage: Lattice Performance



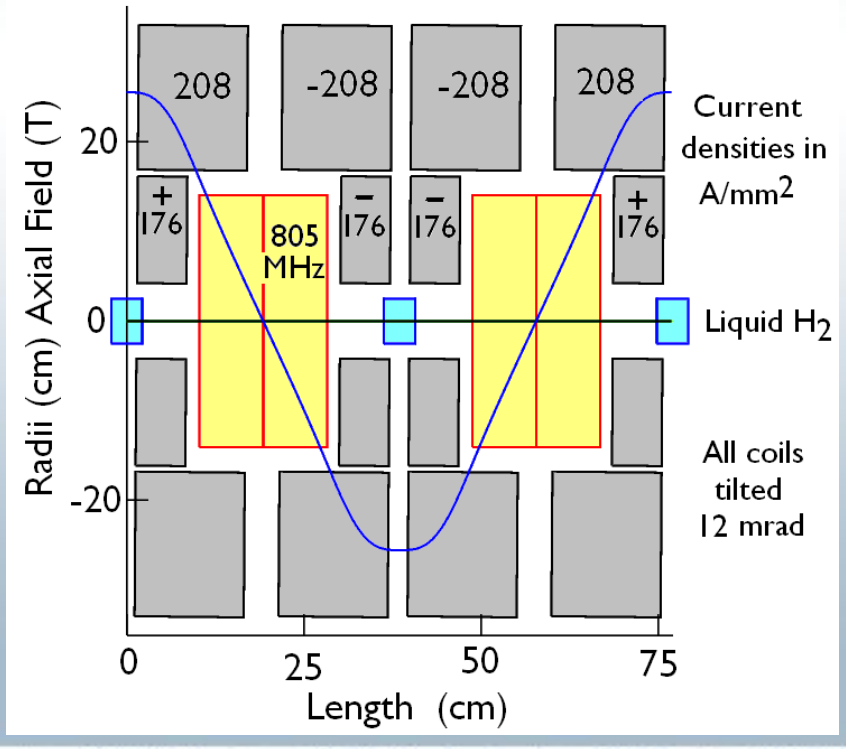




- Stochastics included
- Without muon decay
- No cavity windows
- 500 μm absorber AL windows

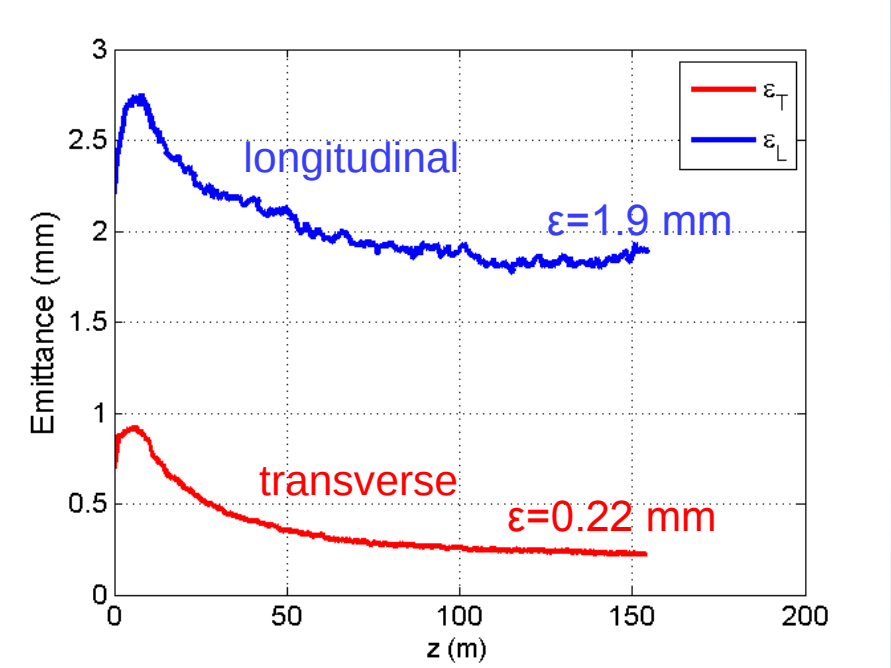
Planar Snake (Late Stage)

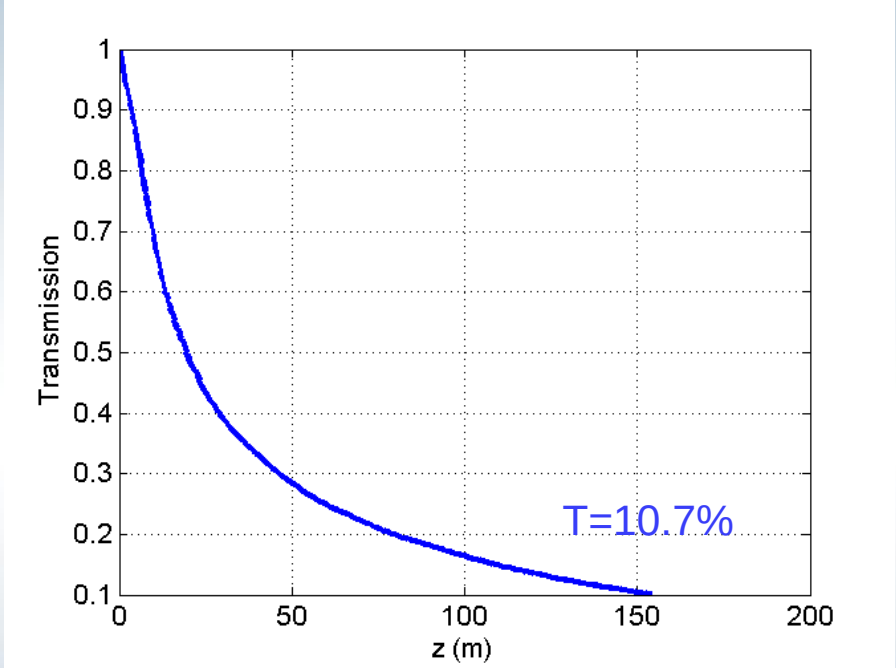
- Equilibrium emittance scales with beta
- MC requires ε (trans) <0.3 mm and thus β < 3 cm
- To achieve this we shorten cell size, increase peak axial field, shorten rf length, increase rf frequency & voltage.



Property	Value
Cell period	0.77 m
RF Frequency/ RF number	805.0 MHz / 4
RF voltage	35.0 MV/m
Synchronous phase	15 deg.
Absorber Length/ Type	4.4 cm/ LH2
Minimal beta function	1.8 cm
Max Field on Coil	25 T
Max Field on Axis	24.2 T

Lattice Performance





- Stochastics included but no muon decay
- No cavity windows, 100 μm absorber AL windows
- Achieve baseline MC parameters but poor transmission

Summary

- A number of different cooling lattices have been designed and simulated the last years.
- Here a new option was presented: A planar snake
- The snake looks attractive:
  - Is linear
  - Cools both signs
  - Most likely has less engineering constraints
- Some results verified with two independent codes
- Work far from complete and more optimizations will be made.